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AN IMPUTATION METHOD FOR ESTIMATING CIVILIAN OPPORTUNITIES AVAILABLE TO MILITARY ENLISTED MEN

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RAND Corporation

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This new method -- suggested by recent research in civilian labor economics -- uses data on retention rates, military pay, and characteristics of enlisted men to estimate the average value of civilian employment opportunities offered to military veterans. The method is illustrated using data for a selected sample of men in Air Force electronics specialities who made reenlistment decisions in FY 1972. Results suggest a reenlistment supply elasticity for these men in the range of 1.5 to 2.5. Estimates also suggest that a 55-percent increase in second-term military pay would induce retention rates near 0.5 for men without dependents. Refs. (BG)

PREFACE

This report was prepared as part of Rand's DoD Training and Manpower Management Program, sponsored by the Human Resources Research Office of the Defense Advanced Research Projects Agency (ARPA). With manpower issues assuming an ever greater importance in defense planning and budgeting, the purpose of this research program is to develop broad strategies and specific solutions for dealing with present and future military manpower problems. This includes the development of new research methodologies for examining broad classes of manpower problems, as well as specific problem-oriented research. In addition to providing analysis of current and future manpower issues, it is hoped that this research program will contribute to a better general understanding of the manpower problems confronting the Department of Defense.

The report describes and illustrates a new method--suggested by recent research in civilian labor economics--for estimating civilian employment opportunities available to military veterans. Although the proposed method cannot be fully investigated with currently available data, the research may serve to warn users of conventional methods about potential shortcomings in those methods and to encourage further methodological advances in this area.

SUMMARY

With an all-volunteer armed force, the U.S. Department of Defense must compete with civilian employers to obtain and retain skilled manpower. Thus, information about civilian employment opportunities is useful to military decisionmakers. To obtain information about the opportunities available to single-term enlisted personnel, previous studies have examined data on veterans' earnings. Recent studies of civilian labor force behavior have suggested, however, that evidence obtained in this way may be misleading; the premises underlying the studies suggest, in particular, that men who choose to separate from the military do so because they have relatively good civilian opportunities, so that the experience of veterans may not be representative of the civilian opportunities available to men who reenlist.

The present report describes the conditions under which this criticism is relevant to studies of veterans' opportunities. Specifically, it is shown that, if civilian returns are stochastic, veterans' experiences will provide (upward) biased estimates of average civilian returns available to enlisted men.

Drawing on research by R. Gronau [1], the report then suggests an alternative estimation method based on a model of the reenlistment decision process. The proposed estimation method uses data on retention rates, military pay, and characteristics of enlisted men to estimate the average value of civilian offers. Notably, because the method does not require data on the civilian experiences of veterans, it avoids the incidental problems of determining civilian earnings of veterans who enter schooling or who are unemployed.

Finally, the report illustrates the method using data for a selected sample of men who made reenlistment decisions in fiscal year 1972 and were in Air Force electronics specialties. Results obtained by means of the empirical analysis suggest a reenlistment supply elasticity for these men in the range of 1.5 to 2.5. The estimates also suggest that a 55-percent increase in second-term military pay would induce retention rates near 0.5 for men without dependents.

ACKNOWLEDGMENTS

This report derives from a lengthy exploration and evaluation of alternative methods for estimating civilian earnings, during which many ideas were generated and blind alleys encountered. During the exploratory period, the author benefited considerably from discussions with Richard Cooper, Dennis De Tray, Bryan Ellickson, Gary Nelson, and Eva Norrblom, as well as from computer assistance provided by Roberta Smith. To an extent insufficiently reflected in the final report, these individuals contributed to a much improved understanding of the issues and problems involved in estimating the civilian opportunities available to enlisted personnel.

With respect to the contents of this report, special acknowledgment is due Gary Nelson and John Enns for their help in selecting the sample and obtaining data for the empirical analysis.

CONTENTS

I. INTRODUCTION

The research presented in this report is part of a larger project concerned with obtaining information about the civilian opportunities facing military personnel. The major objectives of the larger project are to analyze recently available survey data on the civilian labor market experiences of veterans and to test hypotheses about the existence and nature of effects on civilian opportunities of military training and experience. It is hoped that the empirical results of the project will be useful in analyzing such military manpower issues as the effectiveness of military compensation policies in manning military specialties,* the nature of transition problems encountered by newly separated veterans, the contributions of trained veterans to civilian productivity, and the value to various socioeconomic groups of obtaining military training and experience.

Given these empirical objectives, studies in the project generally rely on a familiar methodological approach: the comparison of average earnings of groups of veterans classified by variables such as age, race, education, military training category, and other characteristics. However, as a complement to the empirical studies, the research project also includes an analysis of methodology whose purposes are to re-evaluate estimation techniques in the light of alternative models of earnings determination and to suggest improvements and extensions of the empirical studies. The method proposed and illustrated in this report is an outgrowth of the latter.

The proposed method is based on a model, developed by R. Gronau [1] for civilian labor market analysis, which postulates that earnings offers made to ostensibly identical individuals vary stochastically. According to the model, each individual compares his civilian earnings offer with military reenlistment pay and chooses to separate only if

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*A military specialty is an occupational area to which personnel are assigned and in which the services provide training. To avoid confusion, the term "specialty" refers in this report to a military occupation, while the term "occupation" is reserved for jobs in the civilian sector.

the civilian pay offer is superior. A notable implication of the model is that the average offer received by men who choose to reenlist would be less than the average offer received by men who leave the military. An objective of the method is to obtain an unbiased estimate of the mean of the entire distribution of offers.

Gronau's model provides a basis for imputing the mean of the civilian offers distribution from data on retention rates and military pay. The estimating procedure is described here in detail, then illustrated using data for Air Force electronics specialties from FY 1972. As described in Section III, the application of Gronau's model to the military retention case provides for a method with statistical properties superior to those of Gronau's original application.

Beyond introducing a new application of this model, however, the present study draws on the conceptual basis of previous military retention studies to develop a more comprehensive concept of the returns to civilian employment. On theoretical grounds, the civilian "return" analyzed here is more precisely defined as the value of military pay required to make military reenlistment and separation equally attractive to an individual, given the individual's perception of his civilian opportunities. This measure is conceptually distinct from civilian earnings offers both because the measure may include a "taste" component (i.e., preference for civilian or military life) and because it may reflect inaccurate perceptions. The implications of making a distinction between earnings and (perceived) returns are addressed in Section II.

Section II also describes the conceptual framework of the new method, relating it to principles underlying previous military retention analyses and to the Gronau model. Section III develops the model in a mathematical form and describes the resulting method for analyzing civilian returns. Section IV presents an example of the empirical application of the method to Air Force enlisted men trained in electronics specialties. In the appendix, we apply the method to a special case in which military training is specific to a particular subset of civilian occupations.

II. CONCEPTUAL FRAMEWORK

At the end of a term of military service, an enlisted man may choose among a variety of work and schooling alternatives. The available options may include reenlistment, several civilian jobs, a job search in the civilian labor market, and formal schooling or training. In the conceptual framework underlying this study, we postulate that the nature of alternatives available to an individual are predetermined--arising from the human capital embodied in the individual and from labor market conditions over which he exercises no control--but that the choice among alternatives is subject to discretion. Specifically, we postulate that an individual maximizes utility by means of a choice among available alternatives.

For the most part, the objective of an analysis of civilian opportunities facing veterans is to analyze how available civilian alternatives vary among individuals--in particular, how the alternatives are affected by military training and experience. In conducting the analysis, however, researchers generally use data on the civilian work *experiences* of veterans to estimate how opportunities vary. Since these experiences reflect the outcomes of the choice process, they may provide an inaccurate description of the underlying alternatives and, as is shown below, may even lead researchers to conclude that there is a training effect when none exists.

The potential problem in using the outcomes of choice to analyze available alternatives has been detailed in Ref. 1. Although Gronau's research deals with the civilian labor market activity of women, there is a strong parallel between his case and that of veterans' behavior. Gronau postulates that women face a choice between labor market activity and employment in the home; similarly, enlisted men face a choice between civilian employment and reenlistment. In one version of his model, Gronau shows that if market wages vary stochastically among women with identical characteristics, the average wage received by women who choose market employment is a biased measure of the average wage offer available to the women. Similarly, if there is stochastic variation in the

civilian offers made to identical enlisted men, the average civilian wages of men who separate will be a biased measure of the civilian wage offers available to all enlisted men.

This point is illustrated in Fig. 1a, which shows a hypothetical frequency distribution of civilian wage offers available to enlisted men. For the moment, we assume that the men base the choice between reenlistment and civilian employment solely on a comparison of wages, with the reenlistment wage shown as W_M in the figure. As a result of wage comparisons, men who receive civilian offers greater than W_M accept civilian jobs, while the remaining men reenlist. Thus, although the mean civilian offer in the figure is μ_c, the average wage observed for separatees is

$$\bar{W}_C > \mu_C$$

To carry the analysis a step farther, Figs. 1a and 1b together illustrate the point that a comparison of separatees' wages can result in a spurious impression that military training affects civilian offers. Figure 1b shows a civilian offer distribution identical to that in Fig. 1a but for men trained in a different military specialty; the figures thus illustrate the case in which a difference in training does not affect civilian offers. However, the figures illustrate different military wage rates, $W_M < W'_M$ (where W'_M is for the second training group). Based on the comparison of military and civilian wages, fewer of the men in the second training group separate, and the average civilian wages of those who do separate, $\bar{W}'_C$, is higher than the average for the first training group. Since $\bar{W}'_C > \bar{W}_C$, the comparison of civilian wages for the two training groups would suggest that the second training group receives a civilian return to training even though the average offer, $\bar{W}_C$ (and, in fact, all parameters of the offers distribution) is the same for the two groups.

The estimation problem illustrated in Figs. 1a and 1b is often called "selectivity" bias; the term reflects the fact that observed wages are a preselected sample of offers. The potential for bias arises from the possibility that wage offers vary stochastically among

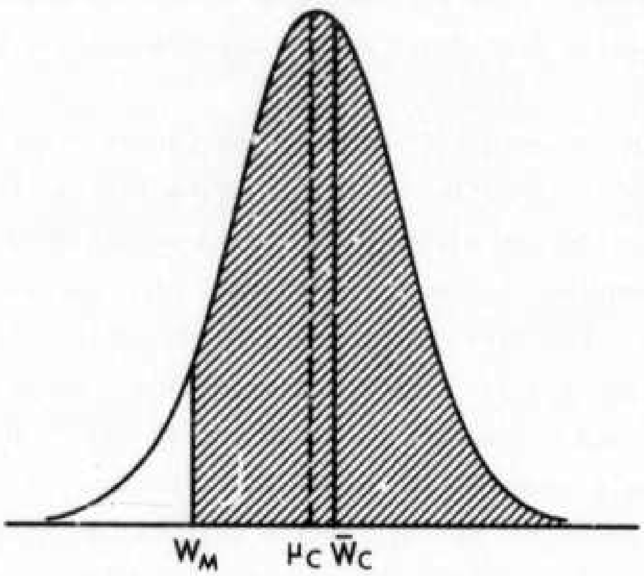

Fig. 1a — Separations and civilian earnings when the military wage = W_M.

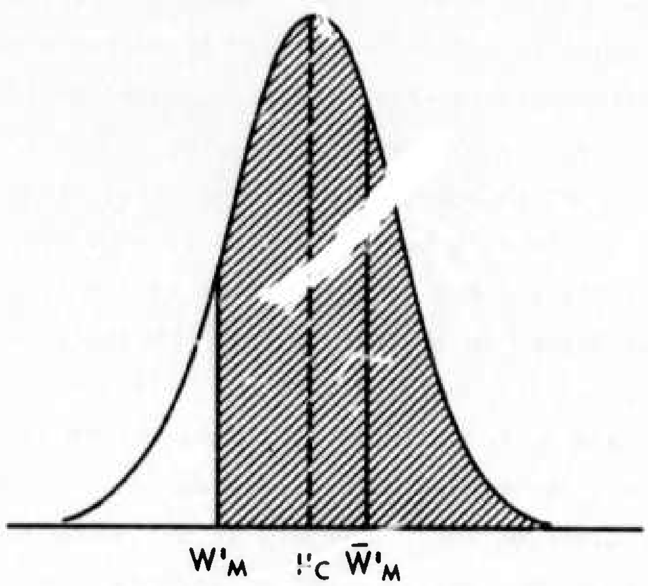

Fig. 1b — Separations and civilian earnings when the military wage = W'_M.

individuals with similar productivity characteristics. In civilian labor market models,* the stochastic variation is typically interpreted as resulting from labor market imperfections such as imperfect information.

Given this conceptual framework, the Gronau study suggests a method of obtaining unbiased estimates of μ_C: From Fig. 1, it is readily apparent that different values of W_M would result in different separation rates among samples of enlisted men. The precise manner in which the separation rates vary as W_M varies is determined by the shape and parameters (such as μ_C) of the W_C distribution. Hence, the Gronau model suggests that data on separation rates and values of W_M might be used to estimate the parameters of the W_C distribution.

Gronau's model and the estimation methodology it suggests offer a promising application to the military manpower issues raised in Section I of this report. The model appears applicable because it offers a plausible explanation for the observation that not all of the enlisted men with identical characteristics who are offered the same military reenlistment pay choose either reenlistment or separation. The method based on this model is appealing because it offers a means of obtaining theoretically unbiased estimates of μ_C using minimal data inputs (i.e., values of W_M and separation rates for groups of enlisted men).

It is important to recognize, however, that because the essential characteristic of Gronau's method is that it *imputes* parameter values of a decision variable, the interpretation of the results obtained by the method thus depend in an important way on the model's assumptions about the nature of the decision variable. If reenlistment/separation decisions are made by comparing actual *wage* offers in the civilian and military sectors, the Gronau method provides an estimate of the mean of the wage-offer distribution. However, if decisions are affected by factors other than wage offers--such as expectations or tastes for military versus civilian employment--then the interpretation of the results from this method can be quite different.

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*For example, in the job-search literature. See Ref. 2.

Notably, in military manpower models of accession and retention behavior,* it is frequently assumed that work choices are not based solely on wage comparisons, but on other factors as well. In particular, the models postulate that individuals differ in their tastes, so that different choices may be observed within a group of individuals whose sets of alternatives are identical. In such studies, this assumption is offered to explain why a given military compensation level induces some men to reenlist but not others, even within quite homogeneous groups.

To show how nonwage factors can be introduced into the model, consider the comparison of offers in a utility-maximizing framework of choice. In principle, an individual compares the net gain in utility to be derived from each available alternative. Utility may derive not only from current wages but from other job characteristics as well, such as location, type of work, and prospects for future advancement. The individual selects the option for which the utility gain is greatest.

Although utility is not generally expressed as a cardinal measure, the relative utility gains from an alternative can be constructed as follows: For the military reenlistment alternative, M, we suppose that wage (W) and nonwage (N) returns can be written as the sum $W_M + N_M$, and similarly for the civilian alternative, C. The difference in returns between the two alternatives is $W_M + N_M - W_C - N_C$. The familiar properties of utility functions imply that there is a wage level in the military alternative, R, which would make this and alternative C equally attractive to an individual. That is, $R + N_M - W_C - N_C = 0$, or $R = W_C + N_C - N_M$. This compensating wage is a dollar measure of the total return in alternative C *relative* to the value of W_M. For expositional convenience throughout the remainder of this report we shall use the term "civilian returns" or "relative civilian returns" to refer to R.

According to this choice model, R is the decision variable to be compared with W_M by individuals making a reenlistment/separation decision. The implication is that Gronau's method would provide an imputed estimate of the mean of R. If, on the average, $N_C - N_M \neq 0$, the mean

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*For a particularly clear example of this reasoning, see Ref. 3.

of R will not equal the mean of W_C. Furthermore, if the average value of $N_C - N_M$ differs among military specialties, differences in the mean of R across specialties will provide an inaccurate measure of differences in the mean of W_C. Thus, it would be necessary to use external information or assumptions to establish the mean of $N_C - N_M$ in order to use the imputation method to address issues involving civilian wages, such as questions concerning the productivity of veterans or the effects of military training and experience on civilian productivity.

Similarly, if one postulates that the reenlistment/separation decision is based on expectations rather than civilian offers actually received, there is a conceptual distinction between the variable estimated by the imputation method and the parameters of the distribution of actual civilian offers. In order to draw conclusions about either wage offers or actual civilian returns from the imputation results, it would be necessary to be able to describe the average accuracy of expectations.

With adequate data, a weak test of the existence of taste and expectation effects could be undertaken. Having estimated the parameters of the expected civilian returns distributions, it is possible to calculate the average value of veterans' wages which would be observed if, on the average, $N_C - N_M = 0$ and expectations were accurate for all enlisted men. If the predicted value of $\bar{W}_C$ were approximately equal to the average of observed veterans' wages, then the simple wage-comparison model could be used with some confidence that the imputation results reflect the parameters of the W_C distribution. If not, they should not be used to evaluate productivity issues.

Presently available data do not permit an investigation of this question. However, inadequate information about the relationship between the imputed estimate of the mean of R and the value of the mean of W_C is irrelevant to the use of the method for analyzing retention behavior. Regardless of the relationship between R and W_C, R is a functional measure of the value of military pay which would make reenlistment and separation equally attractive to an individual, while W_C is not. If W_C is stochastic, the parameters of its distribution

cannot be identified independently of the distribution of R. If W_C is nonstochastic, R is the decision variable most appropriate for explaining the observed variation in decisions among homogeneous individuals facing the same military pay offer. Therefore, a systematic investigation of the parameters of the distribution of R is warranted both as a means of analyzing retention and as a first step in attempting to identify the nature of the retention/separation decision process.

III. MATHEMATICAL MODEL AND METHODOLOGY

This section develops methods by which data on separation rates, military pay, and the characteristics of enlisted men can be used to estimate the average values of civilian returns available to various categories of men. We begin by introducing a model that describes the determination of civilian returns and the separation decisions of individuals. On the basis of this model, we show mathematically that the value of average returns of separatees is a biased measure of average returns available to all enlisted men. We then use the model to derive a preferable estimation approach.

FACTORS DETERMINING OFFERED AND CHOSEN RETURNS

Using the notation of the preceding section, we define (expected) civilian returns as

$$R = W_C + N_C - N_M \tag{1}$$

where W_C and N_C are dollar values of the wage and nonwage benefits from civilian employment, respectively, and N_M is the dollar value of nonwage reenlistment benefits. Conceptually, R is the value of military pay which would make military and civilian employment equally attractive to an enlisted man.

The value of R may vary among enlisted men for several reasons. From labor market theory, the value of W_C (and perhaps job aspects which affect the valuation of N_C) is determined by the characteristics of the individual, such as age, race, education, preservice civilian work experience, mental aptitude, and so on. In addition, military training may affect productivity. Beyond the productivity factors, however, there may be stochastic variations in civilian job offers or in tastes for civilian or military employment. Denoting military training by T and nonmilitary characteristics by a vector X, we postulate that the value of R for an individual is given by

$$R = R(X, T, \varepsilon) \tag{2}$$

where ε is a random variable associated with either tastes or wage offers.

At the end of a term of service, the enlisted man must choose between civilian employment with returns R and military reenlistment at wage W_M. The value of W_M may also vary among individuals as a function of their personal characteristics, military training, and perhaps some random factor, u, i.e.,

$$W_M = M(X, T, u) \tag{3}$$

We assume that u and ε are distributed independently.

We assume that the separation decision of an individual is based on a comparison of W_M and R, with separation occurring if $R > W_M$. Although W_M is observed for all enlisted men, R is (in principle) observable only for men who choose to separate. From Eqs. (2) and (3), it is clear that the value of R that would be observed for separatees is a function not only of X and T, but also of u and ε. We shall now show that if ε (in particular) possesses a nonzero variance, then $\bar{R}$, the average value of separatees' returns, is likely to be a biased estimate of μ, the mean of all values of R.*

To do so, we must select a particular frequency distribution for ε. Although alternative distributions may be plausible, the normal distribution is particularly appealing. Use of the normal distribution for ε implies that, for men with given military and nonmilitary characteristics (X and T), there is a central tendency in the values of R and that the distribution of R is symmetrical around its mean. If stochastic variations in W_C are responsible for the variation in R, we might reasonably expect--as does Gronau--that employers' decisions concerning wage offers would produce a normal distribution for W_C. Alternatively, if we assume that W_C is nonstochastic but tastes vary--as in retention

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*Note that in the previous section we used μ_C to indicate the mean of W_C. Here, μ is the mean of R.

studies--then we are effectively assuming that $N_C - N_M$ is normally distributed; notably, the normal cumulative distribution function (cdf) is similar (except in the extreme tails) to the logistic cdf which is commonly used in retention studies [4]. In either case, use of the normal distribution implies the plausible presumption that small changes in W_M will have a smaller effect on retention when W_M differs greatly from μ than when the values of W_M and μ are close together.

Using the normal distribution, we have

$$f(\varepsilon) = \frac{1}{\sigma_\varepsilon\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{\varepsilon - \mu_\varepsilon}{\sigma_\varepsilon}\right)^2\right] \tag{4}$$

where μ_ε and σ_ε^2 are the mean and variance of ε,* respectively. To simplify the analysis, we restrict our attention to a particular group of individuals for whom $X = X_0$, $T = T_0$. For this group, $R = R_0$ is equal to a constant plus ε. Thus, the frequency function for R_0 is given by

$$f(R_0) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{R_0 - \mu_0}{\sigma}\right)^2\right] \tag{5}$$

where μ_0 is the mean of R_0 and $\sigma^2 = \sigma_\varepsilon^2$ is the variance of R_0.

Since W_M is observable for each individual, we may select individuals for whom W_M is a known constant and for whom, therefore, $X = X_0$, $T = T_0$, and $u = u_0$. (This does not affect the frequency distribution of R_0, because we have assumed that u and ε are independent.) Denoting the value of W_M for these individuals by W_0, we may write the separation probability for this group of individuals as

$$P_0 = \text{Prob}\ (R_0 > W_0) = \int_{W_0}^{\infty} \frac{1}{\sigma\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{R_0 - \mu_0}{\sigma_0}\right)^2\right] dR_0 \tag{6}$$

---

*Note that it is unnecessary to assume that $\mu_\varepsilon = 0$. Such an assumption would be undesirable, since tastes may have a systematic effect on the perceived value of R.

Then the value of $\bar{R}_0$ (the average returns of separatees) is an estimate of the expected value of R_0 given the decision to separate:

$$E(R_0|R_0 > W_0) = \int_{W_0}^{\infty} R_0 \frac{1}{\sigma\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{R_0 - \mu_0}{\sigma}\right)^2\right] dR_0$$

$$= \mu_0 + \frac{\sigma}{P_0\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{R_0 - \mu_0}{\sigma}\right)^2\right] \tag{7}$$

Equation (7) shows that, as long as $\sigma \neq 0$ (and $P_0 \neq 1$), $\bar{R}_0$ is a biased estimate of μ_0. Similarly, a comparison of average separatees' returns may provide a biased estimate of the difference in available civilian returns. Letting R_1, μ_1, and W_1 be the values of R, μ, and W for a group of men for whom $X = X_1$, $T = T_1$, and $u = u_1$, then $\bar{R}_1 - \bar{R}_0$ is an estimate of*

$$E(R_1 - R_0|R_1 > W_1 \text{ and } R_0 > W_0) = E(R_1|R_1 > W_1) - E(R_0|R_0 > W_0)$$

$$= \int_{W_1}^{\infty} R_1 \frac{1}{\sigma\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{R_1 - \mu_1}{\sigma}\right)^2\right] dR_1$$

$$- \int_{W_0}^{\infty} R_0 \frac{1}{\sigma\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{R_0 - \mu_0}{\sigma_0}\right)^2\right] dR_0$$

$$= \mu_0 - \mu_1 + \sigma \left\{ \frac{1}{P_1\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{R_1 - \mu_1}{\sigma}\right)\right]\right.$$

$$\left. - \frac{1}{P_0\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{R_0 - \mu_0}{\sigma}\right)^2\right]\right\} \tag{8}$$

---

*Note that the derivation is made under the assumption that $\sigma_0 = \sigma_1 = \sigma$, which follows directly from Eq. (2) if σ_ε is independent of X and T.

If $P_0 \neq P_1$,* $\bar{R}_1 - \bar{R}_0$ is a biased estimate of $\mu_1 - \mu_0$. The same conclusion would also apply, for example, if regression analysis were used to relate values of R for separatees to their characteristics and training (X and T).

A METHOD FOR DEALING WITH SELECTIVITY BIAS

An alternative estimation methodology is suggested in Ref. 1. The cases examined by Gronau are not strictly comparable to the case under consideration here, in which μ_0 is unknown but W_0 is observable. However, the Gronau approach can be modified to deal with the present case; in fact, as we shall see, the case of civilian alternatives for enlisted men provides an exceptionally appropriate application.

The method is based on the observation that

$$P_0 = \text{Prob } (R_0 > W_0) = \text{Prob} \left(x_0 = \frac{R_0 - \mu_0}{\sigma} > y_0 = \frac{W_0 - \mu_0}{\sigma} \right) \tag{9}$$

Since x_0 is a standard normal variable, a table can be used to estimate a value of y_0 corresponding to any value of P_0. An estimate of P_0 is given by the separation rate of enlisted men in the group for which $X = X_0$, $T = T_0$, and $u = u_0$. From the substitution for y_0 in Eq. (9), then

$$y_0 = \frac{1}{\sigma} W_0 - \frac{\mu_0}{\sigma} \tag{10}$$

where y_0 is estimated from a table of standard normal deviates and W_0 is observed.

In principle, Eq. (10) can be used as the basis of an estimating equation. In the equation, μ_0 and σ are fixed parameters and W_0 is exogenous, while y_0 is endogenous. From Eqs. (2) and (3), μ_0 and σ are equal for all individuals for whom $X = X_0$ and $T = T_C$. However, it is possible for W and (therefore) y to vary while X, T, σ, and μ are

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*If $P_0 = P_1$, then $W_1 - W_0 = \mu_1 - \mu_0$, and the returns of separatees would not be needed to estimate $\mu_1 - \mu_0$.

constant. That is, the value of u in Eq. (3) can vary. Letting subscript i refer to alternative values of u, and y_i^* represent the estimate of y_i, the estimating equation becomes

$$y_i^* = \alpha W_i - \beta + \omega_i \tag{11}$$

where $\alpha = 1/\sigma$, $\beta = \mu_0/\sigma$, $\beta/\alpha = \mu_0$, and ω_i is an error term reflecting measurement error in the estimate of the dependent variable, y_i.† If, within a category of men with identical military training and nonmilitary characteristics (T and X), there are enough groups with different military wages (W), then the parameters α and β can be estimated.

Unfortunately, sample sizes can be a constraint in this analysis. Although some categories of enlisted men are sufficiently large and diverse to permit the formation of several subgroups, other categories do not exhibit a sufficient number of subgroups varying in values of W. Therefore we seek a means of extending the method to combine categories so as to permit larger samples for estimation.

If, in Eq. (1), the distribution of ε is independent of X and T, then, in Eq. (11), α is invariant with respect to X and T and β is a function only of X and T. Hence, letting a k subscript indicate groups of men for whom $X = X_k$ and $T = T_k$, we may write

$$\beta_k = f(X_k, T_k) \tag{12}$$

Suppose, for example,‡ this relationship is given by

$$\beta_k = \gamma_X X_k + \gamma_T T_k \tag{13}$$

Then Eq. (11) may be written

$$y_k^* = \alpha W_k - (\gamma_X X_k + \gamma_T T_k) + \omega_k \tag{14}$$

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†The properties of the error term are discussed in Section IV.

‡Interaction terms for X and T might also be specified.

where y^*_{ik} is the value of y^* for men with characteristics X_k and T_k and for whom $W = W_k$.

If the values γ_X and γ_T are invariant for all X and T, then a single estimating equation, given by Eq. (14), can be estimated for all enlisted men. Note, furthermore, that civilian returns could be projected even for combinations of X and T which are not observed, as when, for example, military assignment is such that a high school diploma is required for men to be assigned to a particular specialty and, therefore, no individuals with less than a high school education are observed in the specialty.

Although (as described in Section II) the model underlying Eq. (14) differs from Gronau's in the interpretation of the decision variable (R), the model is similar to Gronau's in that it assumes individuals choose between only two alternatives. If, instead, one postulates that enlisted men face multiple civilian alternatives (e.g., professions or trades), each with its own distribution of returns, the model becomes much more complex mathematically. The appendix discusses the implications of multiple civilian alternatives, showing that under certain conditions Eq. (14) is nevertheless properly specified for estimating civilian returns parameters.

Beyond the conceptual difference between Gronau's model and that used here, the estimation methodology described by Eq. (14) differs in statistical characteristics from the former's methodology. The source of the difference is the nature of the empirical problem to be solved. In our case, we observe all offers in one alternative and can select samples of individuals for whom the offers in this alternative are equal. From observing the choices of individuals in the sample, we seek to determine the average offer in a second alternative. For Gronau, who is dealing with women's choices between market and home employment, only accepted offers in the market alternative and no returns to the home alternative are observed. To even begin to solve the problem, Gronau must assume that there is zero variance in offers for one or the other of the two alternatives, and must empirically analyze the results under both the variance assumptions. Each of the variance assumptions yields

empirical methods which have undesirable econometric properties.[†] In one of the two methods, the true mean of market offers (μ in our notation) is used as a dependent variable, even though this value is exogenous, and in the second method, the market participation rate is used as an explanatory variable even though this value is endogenous.[‡] In contrast, Eq. (14) utilizes exogenous (or predetermined) variables (W, X, and T) to "explain" an endogenous variable (y^*). Equation (14) is the basis for the illustrative empirical example presented in the next section.

[†]For estimating the shadow wage of women's work at home, Heckman's estimation approach is preferable to Gronau's. His method is to simultaneously estimate home-wage and market-wage equations, assuming that market work hours are variable. However, Heckman's approach is not relevant to the problem analyzed here. First, the reenlistment decision is essentially a binary choice; men cannot set hours in both the civilian and military sectors such that asking and offered wages are equated. Second, we have considerably more information about military wages than Gronau or Heckman have about the home wages of women; hence we are in a position to assume, reasonably, that we can observe military wage rates. See Ref. 5.

[‡]Personal communication with John Cogan.

IV. EMPIRICAL ILLUSTRATION: AIR FORCE ELECTRONICS SPECIALTIES

In this section we apply the preceding method to data on separation rates and military pay for enlisted men in Air Force electronics specialties. Although we plan ultimately to compare these results with those for other specialties and with results from more conventional earnings estimation approaches, data appropriate for the comparative analyses are not currently available. Thus, the purpose of this section is to provide an illustration of the method rather than an evaluation of its practical merits.

The equations to be estimated are based upon

$$y_i^* = \frac{1}{\sigma} W_i + \frac{1}{\sigma} \mu + \omega_i \tag{15}$$

where i = a subgroup identifier,

y^* = the value of a standard normal variate x for which the probability of observing values of x greater than y^* is equal to the separation rate of subgroup i,

W_i = the value of military pay for subgroup i,

σ = the standard error of civilian returns, to be estimated,†

μ = the mean of a civilian returns, to be estimated,†

ω = an error term due to the estimation of y_i^*.

To conduct the analysis, we require several subgroups of men among which W_i and y_i^* vary but for which σ and μ can be assumed invariant.

In the equations reported here, we use data for white high school graduates who enlisted in the Air Force prior to age 19½, were assigned to electronics specialties, and made reenlistment decisions during FY 1972. Such men probably had little preservice civilian labor force experience and had similar military training and experience, so that μ and σ would not vary among members of the sample. However, since

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†Constant across subgroups.

the electronics specialties include both "Specialists" and "Repairmen," whose training and experience may differ systematically, we test the hypotheses that μ and σ differ between these two categories. Moreover, since military pay and perhaps tastes vary between men with and without dependents, we use dependency status (a dichotomous variable) to form two additional categories. Thus there are four subsamples under consideration: Repairmen with and without dependents and Specialists with and without dependents.

The subgroups within these subsamples are formed by the individual electronics specialties, indicated by five-digit Air Force occupation codes. Differences in the Variable Reenlistment Bonuses (VRB) and Proficiency Pay (ProPay) levels among the specialties provide the major sources of variation in military pay for the analysis.

MEASURING MILITARY PAY

In principle, the measure of military pay, W, should be the present value of the expected earnings stream for the individual consequent upon his decision to reenlist for a second term. (Separation/retention decisions at each future decision point would have to be taken into account.) It is costly and time-consuming to attempt such a calculation. For present purposes, a simplified measure seems appropriate. The simplification used here is to calculate military pay only through the four-year reenlistment term. Thus, instead of measuring W_i, we measure

$$W_i^* = W_i - H_i \tag{16}$$

where H_i = the present value of expected earnings after the second term. We assume that, at least within each of the subsamples under consideration, H is a constant across subgroups. A property of Eq. (15) is that the difference between μ and the measure of military pay is maintained under linear transformations of the military pay variable. Therefore, if we use W_i^* instead of W_i, we obtain an estimate

$$\mu^* = \mu - H \tag{17}$$

If H is also equal to the present value of civilian returns (i.e., returns consequent upon separation) beyond the period corresponding to the second term, then μ^* is the value of civilian returns for the four years following separation; if the equivalence does not hold, μ^* is nevertheless an estimate of the value of military pay for the second term necessary to induce a reenlistment rate of 0.5.

In measuring W_i^*, we use FY 1973 pay rates as though they would be maintained throughout the second term. In effect, we assume that the men in the sample knew of the FY 1973 rates and that they expected pay raises beyond FY 1973 just sufficient to offset expected inflation and discounting.†

Two potential errors in specifying the pay variable, both due to a lack of data to make it possible to correct the specification, are ignored in the analysis. First, we do not make a discounting adjustment depending on whether the VRB award was paid as a lump sum or in annual installments. If the proportions of each subgroup's reenlisted men receiving each form of VRB award is uniform across subgroups, the failure to make an adjustment should have little effect on the estimated coefficients.‡

Similarly, we do not make an adjustment for whether the men were in pay grade E-4 or E-5 at the time of reenlistment; instead, we use an average measure of pay in the two grades. The discrepancy in pay between the two grades is fairly small (roughly 5 percent), and the proportions of men in the two grades are nearly constant across subgroups.

For each subgroup, then, the military pay variable is computed as

$$W_i^* = 4\text{RMC}_i + 48(50)\text{ ProPay level}_i + 4\text{ base} + 4(\text{VRB level}_i)(\text{base}) \qquad (18)$$

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†Thus, if the men expected 5 percent inflation and had discount rates of 5 percent, we assume that the men also expected their pay to rise by 10 percent per year.

‡The error in the W^* variable implies that the estimate of $1/\sigma$ is biased toward zero; the calculation of μ would be biased as well.

where RMC_i = annual Regular Military Compensation,[†] including the subsistence level for men with two dependents in subsamples with dependents, paid for four years,

ProPay $level_i$ = the multiple of \$50/month designated as the proficiency pay level, paid monthly for four years,

(4 base) = the regular reenlistment bonus, paid to all men in the sample, equal to one month of basic pay for each year of reenlistment,

4(VRB $level_i$) base = the VRB award, determined by a specialty-specific multiple of monthly basic pay for each year of reenlistment.

The values of W_i^* used in the analysis are presented in Table 1, together with the values of y_i^*, the subgroup reenlistment rates (r), and the subgroup sample sizes (n) for each of the four subsamples of data.

SPECIFICATION

As is apparent in Table 1, the subgroups used in the analysis vary considerably in sample size, n. For each subgroup, we are using the proportion of men who separated as an estimate of the separation probability from which y_i^* is estimated. The error in estimating the probability is an inverse function of $\sqrt{n}$. Thus, we expect ω in Eq. (15) to be inversely correlated with $\sqrt{n}$.[‡] To deal with this condition, all the estimating equations are weighted by $\sqrt{n}$.

The specification of Eq. (15), with weighting, is the basic specification for each of the four subsamples. In addition, two other specifications are used. In one, we test the hypothesis that Repairmen

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[†] The sum of basic pay, basic allowance for quarters, subsistance allowance, and a federal tax advantage on the nontaxable allowances.

[‡] The error will also be correlated with the value of the true probability. We have not attempted to deal with this more complex source of heteroscedasticity.

Table 1

DATA USED IN THE EMPIRICAL ANALYSIS OF
AIR FORCE ELECTRONICS SPECIALTIES

Sample/ Specialty Subgroups	r[a]	y^*	W^*	n[b]
Repairman, no dependents				
304x0	0.099	-1.29	$32,900	121
304x4	0.114	-1.21	29,284	280
304x1	0.111	-1.22	32,900	54
303x1	0.064	-1.53	31,092	47
303x2	0.078	-1.42	29,284	153
303x3	0.059	-1.57	29,284	68
321x0	0.114	-1.21	32,900	35
322x1	0.005	-1.60	29,284	109
306x0	0.283	-0.57	43,716	191
362x2	0.154	-1.02	32,900	13
363x0	0.027	-1.93	29,284	73
304x5	0.143	-1.07	41,316	7
302x0	0.190	-0.88	32,900	21
Specialist, no dependents				
307x0	0.125	-1.15	36,516	80
308x0	0.250	-0.97	36,516	8
308x0	0.118	-1.19	29,284	136
325x0	0.202	-0.84	29,284	84
328x1	0.066	-1.51	29,284	76
328x3	0.370	-0.33	31,752	73
328x4	0.224	-0.76	29,284	67
329x0	0.333	-0.43	41,316	3
328x2	0.167	-0.97	29,284	12
316x1	0.057	-1.58	32,900	53
316x1	0.205	-0.66	35,368	39
316x2	0.167	-0.97	29,284	6
317x0	0.458	-0.11	41,316	9
314x1	0.125	-1.15	29,284	8
342x0	0.348	-0.39	41,316	23
343x0	0.300	-0.52	41,316	10
324x0	0.111	-1.22	31,092	18
325x1	0.103	-1.27	36,516	39
326x1	0.417	-0.21	29,284	12
326x2	0.162	-0.99	29,284	37

Table 1--Continued

Sample/ Specialty Subgroups	r[a]	y*	W*	n[b]
Repairman, with dependents				
304x0	0.342	-0.41	$35,368	117
304x4	0.311	-0.49	31,752	235
304x1	0.366	-0.34	35,368	41
303x1	0.269	-0.62	33,560	52
303x2	0.350	-0.39	31,752	123
303x3	0.226	-0.75	31,752	53
322x1	0.174	-0.94	31,752	86
323x0	0.235	-0.72	31,752	17
306x0	0.534	0.01	46,184	174
363x0	0.172	-0.95	31,752	64
304x5	0.533	0.01	43,784	15
302x0	0.524	0.01	35,368	21
Specialist, with dependents				
302x1	0.167	-0.97	31,752	6
307x0	0.402	-0.25	38,984	92
308x0	0.308	-0.50	38,984	13
328x0	0.362	-0.35	31,752	105
325x0	0.379	-0.31	31,680	58
328x1	0.244	-0.69	31,752	41
328x3	0.488	-0.31	31,752	84
328x4	0.460	-0.10	31,752	63
329x0	0.444	-0.14	43,784	9
328x2	0.250	-0.68	31,752	12
316x1	0.256	-0.66	35,368	39
316x0	0.519	0.05	43,784	52
316x2	0.667	0.43	31,752	9
317x0	0.870	1.13	43,784	23
341x1	0.667	0.43	31,752	9
342x0	0.682	0.47	43,784	47
343x0	0.615	0.29	43,784	13
345x0	0.667	0.43	43,784	3
324x0	0.556	0.14	33,560	9
325x1	0.296	-0.54	38,984	27
326x1	0.471	-0.07	31,752	17
326x2	0.371	-0.33	31,752	35

[a]Reenlistment rate.

[b]Numbers of observations per subsample.

and Specialists differ in the value of μ but not σ. Thus, for each of the two dependency subsamples, we estimate

$$y_i = \alpha W_i^* - \beta + \gamma D_{Ri} + \varepsilon_i \tag{19}$$

Letting μ_S = mean civilian returns for Specialists, μ_R = mean civilian returns for Repairmen, and D_R = a dummy variable for the Repair subgroups, then Eq. (19) implies

$$\alpha = \frac{1}{\sigma}; \qquad \beta = \frac{\mu_S}{\sigma}; \qquad \text{and} \qquad \gamma = \frac{\mu_R - \mu_S}{\sigma}$$

Thus, if the estimate of γ is statistically significant, we would conclude that Repairmen and Specialists face civilian returns distributions that differ in their means. However, in drawing this conclusion, we seek some evidence that the assumption that σ is the same for the two types of specialties is reasonable.

Similarly, we consider the implications of the assumption that σ is identical for the two dependency subsamples. In this case, however, we are particularly interested in the hypothesis that the measure of military pay, W^*, does not adequately reflect differences in military pay resulting from differences in dependency status--pay differences due to payments in kind, such as free or subsidized medical care and food purchasing. Therefore, we also estimate

$$y_i = \alpha' W_i^* - \beta' + \gamma' D_{Ri} + \delta D_{Di} + \varepsilon_i' \tag{20}$$

where δ is a parameter to be estimated and D_{Di} is a dummy for subgroups of men with dependents.

Unfortunately, we cannot determine whether the coefficient estimate of δ reflects a difference in the mean of civilian returns (due, say, to differences in tastes between men with dependents and those without) or the unmeasured value of military payments in kind. Nevertheless, the estimate of δ does provide a measure of the amount by which the

military pay of men without dependents would have to rise to induce retention rates like those of men with dependents--and the estimate can be compared with the cost to the services of providing the nonpay compensation currently available to men with dependents.

EMPIRICAL RESULTS

Results from estimating Eqs. (15), (19), and (20) are presented in Table 2. With the sole exception of the equation estimated for Specialists without dependents (Eq. (4) in the table), all the equations yield the expected signs and high statistical significance for all the coefficients. Since the coefficient of W^* is not significant in the estimated Eq. (4), the results for both σ and μ are suspect in this equation, and shall not be given much weight in the discussion that follows.

It is of immediate interest to note the similarity of the estimates of σ among the equations. Since σ is in the relatively narrow range of \$17,000 to \$25,000 and does not differ significantly among the equations, it is reasonable to suppose that the equations which assume σ is equal across subsamples (Eqs. (1), (6), and (7) in the table) are correctly specified. Indeed, Eq. (1) in the table, which applies to the entire sample, is well representative of the results for the various subsamples.

From Eq. (1), mean civilian returns (for the entire four-year period of the second term) for men without dependents are about \$55,000 for Specialists and about \$60,000 for Repairmen. The difference in mean returns is statistically significant at better than 1-percent confidence. These estimates can be compared to the average value (for four years) of W^* for the sample: \$34,596. By implication, it would require a more than 55-percent increase in military pay to induce a reenlistment rate of 0.5 among these men.

Moreover, Eq. (1) implies that men with dependents behave as though having dependents results in an increment to military pay (or a reduction in mean civilian returns) of about \$15,000. That is, \$15,000 is an estimate of the amount which would have to be paid to men without dependents during the second term to produce retention rates similar to those of men with dependents.

Table 2

EMPIRICAL RESULTS AND ESTIMATED MEANS AND STANDARD ERRORS OF CIVILIAN RETURNS FOR AIR FORCE ELECTRONICS SPECIALTIES

(FY 1972)

Sample	Coefficients (Equations Weighted by $\sqrt{n}$)						Estimated Parameters				
	Equation	$\bar{R}_2$	Constant	Military Pay	Repair Dummy	Dependency Dummy	$\mu_{Specialist}$	μ_{Repair}	$\sigma_{Specialist}$	σ_{Repair}	Dependents[a]
Combined	(1)	0.84	-2.426 (10.27)	0.44E-04 (6.322)	-0.262 (-3.682)	0.6596 (9.032)	$54,468	$60.350	$22,452[b]	$22,452	$14,807
Repairman, no dependents	(2)	0.89	-3.183 (-8.750)	0.59E-04 (5.388)	---	---	---	53,505	---	16,810	---
Repairman, with dependents	(3)	0.68	-2.019 (-5.530)	0.45E-04 (4.340)	---	---	---	45,330	---	22,452	8,000[c]
Specialist, no dependents	(4)	0.63	-1.552 (-2.252)	0.18E-04 (0.8357)	---	---	87,486	---	56,370	---	---
Specialist, with dependents	(5)	0.38	-1.628 (-2.998)	0.40E-04 (2.634)	---	---	40,477	---	24,863	--	(d)
All, no dependents	(6)	0.82	-2.465 (-6.546)	0.46E-04 (4.048)	-0.283 (-2.511)	---	53,459	58,447	21,687	21,687	---
All, with dependents	(7)	0.64	-1.726 (-5.519)	0.43E-04 (4.966)	-0.239 (-2.674)	---	40,130	45,692	23,250	23,250	13,500[c]

[a] Additional value of military pay implied by comparing behavior of men with and without dependents.

[b] Estimated under the constraint that $\sigma_{Specialist} = \sigma_{Repair}$.

[c] Approximate. Computed by assuming estimated value of μ for men without dependents (preceding equation) is correct.

[d] Calculated value omitted due to poor explanatory power of Eq. (4).

A final note on the empirical results concerns the reenlistment supply elasticities implied by the estimates of μ and σ for the various subsamples. The empirical results shown in Table 2 suggest that a 1-percent increase in W^* would result in a 1.5- to 2.5-percent increase in the reenlistments, depending on the sample under consideration.

CONCLUDING REMARKS

These empirical results are illustrative, based on several simplifying assumptions. However, the results are reassuring in that the estimates appear reasonable and the estimating equations yield quite good statistical properties. Moreover, the analysis is not exceedingly complex computationally. Thus, it appears that the new method is promising and worthy of further testing and evaluation.

Appendix

A SPECIAL CASE: MULTIPLE CIVILIAN ALTERNATIVES

In Section III we postulated that there is a single distribution of civilian returns and that military training, if useful in the civilian sector, results in a shift in the returns distribution. Thus the analysis treated entry into the civilian sector as a single alternative facing enlisted men--an alternative within which there is stochastic variation in offers but for which there exists central tendency in offers. In reality, there may be many differentiated civilian options: various jobs, schooling, unemployment, etc. A particular individual may perceive a set of civilian offers corresponding to these various options and may face a choice not only between the civilian and military sectors but among civilian alternatives as well.

Nevertheless, in some circumstances, the model based on a single civilian alternative may provide a reasonable approximation to behavior. If there are a great many options from which to choose and if each option exhibits central tendency and stochastic variability in offers, the distribution of relevant offers (i.e., a relevant offer is the "best" offer in any set of offers) may be well approximated, say, by a normal distribution. Moreover, if individual characteristics, such as military training, are useful in all the alternatives, then it may be a good approximation to assume that the distribution of all relevant offers shifts in response to differences in individual characteristics. Then the method of Section III--with the virtue of computational simplicity--may be both useful and reasonably precise.

On the other hand, it is plausible to suppose that military training is not equally useful in all sectors of the civilian economy. Many military specialists provide highly technical training, such as in electronics repair or nuclear technology. While these skills may be very valuable in some civilian occupations, it seems likely that such training would have little or no value in unrelated civilian fields.

If military training is occupation-specific, there may be a greater tendency for men with particular training to enter a related civilian

field in order to reap the wage benefits of higher productivity in that field. In the extreme case, in which men in each training group enter a related civilian occupational area, the method of the preceding section may still be useful; if one postulates that the offers distribution in each civilian field is approximately normal and all the distributions have about the same variance, σ^2, then one might view the effect of training as a shift in the offers distribution that coincides with a change in civilian occupational area.

However, it does not appear to be the case that all men from a training group with similar characteristics choose a single occupational area. Some casual evidence to the contrary is shown in Table A-1, where the distributions among civilian occupations are shown for white high school graduates from each of six military specialties. The figures show that many civilian occupational areas are chosen. However, the figures also show some tendency for a relatively larger proportion of separatees from each specialty to choose a related civilian field. This is apparent from the boxed figures, which indicate the proportion of a specialty's separatees entering a related civilian field; for example, the table shows that whereas 5.5 percent of the separatees with military training in medical fields enter civilian careers in medicine and health, less than 1 percent of the separatees from other specialties enter this occupational category.

Thus, it may be useful to consider the problem of estimating civilian returns for alternative civilian occupations. Unfortunately, the general case of multiple alternatives is exceedingly complex mathematically. Suppose, for example, we postulate that there are K alternatives, $k = 1, \ldots, K$, such that $R_k \sim N(\mu_k, \sigma_k^2)$. Each individual receives one randomly selected offer from each alternative and then compares the maximum of these offers $(\max_k R_k)$ with W_M. Then, the separation probability is given by

$$\text{Prob } (W_M < \max_k R_k)$$

If the distribution of R in each alternative is normal, the distribution of $\max R_k$ is not a well-behaved function. Rather than pursue this

Table A-1

OCCUPATIONAL DISTRIBUTION BY SPECIALTY: PERCENTAGE OF SEPARATEES[a]

	91B Medical Specialists	010 Infantry	63H Engine and Powertrain Repair	63B Wheel Vehicle Mechanic	800 Food General	121 Missile Guidance and Control
Professional						
00-05 Sciences, professional	---	1.4	---	1.2	2.4	$\boxed{8.3}$
07 Medicine, health	$\boxed{5.4}$	0.1	---	---	---	0.9
09 Education	0.7	---	---	---	---	---
10-19 Art, library, entertainment, etc.	3.8	2.0	1.1	3.6	4.9	6.4
Clerical and Sales						
20-29	18.1	13.4	11.2	9.7	7.3	---
Service Occupation						
30-38 (i.e., food preparation services, police and firemen, etc.)	21.5	6.6	2.2	5.5	$\boxed{19.9}$	5.5
Farming, Fishery, etc.						
40-46	---	0.9	2.2	3.4	1.8	---
Processing						
50-59	8.8	5.7	5.5	4.5	8.5	6.4
Machine Trades						
60-69 (i.e., mechanics, etc.)	8.2	11.9	$\boxed{25.9}$	$\boxed{24.1}$	10.3	13.6
Bench Work						
70-79 (i.e., electronics repair)	3.7	6.3	7.9	5.5	6.1	6.4
Structural Work						
80-89 (i.e., construction)	10.7	25.6	18.9	16.2	13.0	18.6
Miscellaneous						
90-97 (i.e., bus and truck drivers, graphic art, etc.)	16.1	21.1	21.3	22.1	24.3	16.7
Sample Size	128	414	88	137	160	106

[a]High school graduates, not in education program, working full time.

abstruse and intractable analysis, we shall consider a special case embodying certain simplifying but not implausible assumptions.

First, we shall consider only two civilian alternatives: one consisting of those occupations which, on *a priori* grounds, would seem to be related to a given military specialty, and a second alternative consisting of all other civilian occupations. Second, we shall assume that characteristics of individuals which affect either job-search behavior or productivity imply that a given individual receives offers in each alternative which place him in the same relative position on the two offers distributions. That is, if the offered returns in alternative A is R_A from a normal distribution with mean and variance μ_A and σ_A^2, and similarly for alternative B, then for each individual*

$$\frac{R_A - \mu_A}{\sigma_A} = \frac{R_B - \mu_B}{\sigma_B} \qquad \text{(A-1)}$$

Finally, let alternative B be the set of civilian occupations related to the military specialty under consideration, and let A be all other occupations. Provided the set of "related" occupations (alternative B) represents a small set of fairly homogeneous occupations whereas alternative A is large and varied, we may plausibly assume that $\sigma_B < \sigma_A$.

Rewriting Eq. (15), we have

$$R_A = (\sigma_A/\sigma_B)R_B - (\sigma_A/\sigma_B)\mu_B + \mu_A \qquad \text{(A-2)}$$

Thus, $R_A > R_B$ if†

$$R_A > \sigma_A\mu_B - \mu_A\sigma_B/(\sigma_A - \sigma_B) \qquad \text{(A-3)}$$

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*Note that, under this assumption, if $\sigma_A = \sigma_B$, all individuals will always choose either R_A or R_B. Thus, if like individuals choose different civilian alternatives, this model can hold only if $\sigma_A \neq \sigma_B$.

†This condition relies critically on the assumption that $\sigma_A > \sigma_B$.

We assume that individuals compare W_M, R_A, and R_B and select the alternative corresponding to the highest of these three values. We know that alternative A is preferred to B for all values of R_A satisfying the condition given by Eq. (A-3). Therefore, if W_M also exceeds the right-hand term of Eq. (A-3), all individuals will choose either to reenlist or to enter A. However, we are interested in the case in which B is also sometimes chosen. Therefore, in the case of interest, it must be true that

$$W_M < \frac{\sigma_A \mu_B - \mu_A \sigma_B}{\sigma_A - \sigma_B} \tag{A-4}$$

Thus far, the model implies the following choice behavior:

1. If $R_A > \sigma_A \mu_B - \mu_A \sigma_B / \sigma_A - \sigma_B$, then alternative A is chosen.
2. If $R_A < \sigma_A \mu_B - \mu_A \sigma_B / \sigma_A - \sigma_B$ and $R_B > W_M$, then alternative B is chosen.
3. If $R_B < W_M$ or (from Eq. (16) if $R_A < (W_M - \mu_A)(\sigma_A/\sigma_B) + \mu_B$, then the individual reenlists.

From item 3, it is clear that the probability of a separation (into either A or B) is

$$\text{Prob (Sep.)} = \text{Prob } (R_B > W_M)$$

$$= \text{Prob}\left(\frac{R_B - \mu_B}{\sigma_B} = x_B > \frac{W_M - \mu_B}{\sigma_B} = y_B\right) \tag{A-5}$$

Note that this result implies that the values of μ and σ in Eq. (10) could be interpreted under the model presented here as the mean and standard deviation of returns in civilian occupations related to the specialty under consideration. That is, if y_B is the value of a standard normal deviate for which a particular separation rate is observed, then

$$y_B = \frac{W_M}{\sigma_B} - \frac{\mu_B}{\sigma_B} \tag{A-6}$$

Thus, we may estimate μ_B and σ_B from Eq. (11) to be

$$y_i = \alpha' W_i - \beta' + \omega_i \tag{A-7}$$

where the sample consists of individuals with identical personal and military characteristics and i refers to subsamples with differing military pay offers, but where the interpretation of the coefficients is $\alpha' = 1/\sigma_B$ and $\beta' = \mu_B/\sigma_B$.

In contrast to the analysis of the preceding section, however, it should be noted that the set of related civilian occupations comprising alternative B may differ among military specialties. Thus it is to be expected that both the variance to be estimated (σ_B^2) and the role of nonmilitary characteristics in determining μ_B may differ among training groups. Hence, although the estimating sample may be increased by considering individuals from a specialty who differ in their nonmilitary characteristics (X), care must be exercised if samples from alternative military specialties are to be combined. The principle on which specialties may be combined is that the "A" and "B" civilian occupations should be similar. For example, one might combine electronics repairmen with electronics technicians.

Suppose, then, that μ_B and σ_B have been estimated using Eq. (A-7). To complete the analysis, it is necessary to estimate μ_A and σ_A. From the preceding description of choice behavior, we know that if

$$R_A > \sigma_A\mu_B - \mu_A\sigma_B/(\sigma_A - \sigma_B) ,$$

alternative A is chosen. Therefore, the probability that A is chosen is given by

$$\text{Prob (A)} = \text{Prob}\left(R_A > \frac{\sigma_A\mu_B - \mu_A\sigma_B}{\sigma_A - \sigma_B}\right)$$

$$\text{Prob}\left(\frac{R_A - \mu_A}{\sigma_B} > \frac{\sigma_A(\mu_B - \mu_A)}{\sigma_B(\sigma_A - \sigma_B)}\right) \tag{A-8}$$

Once we have defined the set of civilian occupations to be included in alternative A, the sum of the rates at which each of the occupations is chosen is an estimate of the probability given by Eq. (A-8).

Unfortunately, even though μ_B and σ_B have been estimated, Eq. (A-2) yields but a single equation in two remaining unknowns: μ_A and σ_A. Therefore, in order to obtain an estimate of μ_A, extraneous information must be used to obtain a measure of σ_A.

There is no ultimate solution to this problem. One possibility is to use measures of σ_A derived from civilian data on earnings by occupation. Although such a measure is not entirely appropriate (because it omits variation due to tastes), the model used here assumes that military training is general in its application to occupations in category A, so that the civilian measure may be a good approximation to the variation in earnings offers to enlisted men. However, to be consistent with the present model, the estimate of σ_A should exceed the estimated value of σ_B.

Fortunately, for the purposes of retention analysis, it is unnecessary to estimate either μ_A or σ_A. Since Eq. (A-7) is derived using the overall separation rate to calculate Y_i, its results are sufficient to estimate the retention response to variations in military wages.

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